Use of Non-spherical Gravity Harmonics for Relative Motion GN&C. (Category 2)

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David M. Henderson
TRW Houston
Phone: 713-333-3133
FAX 713-333-1875

Abstract:
Detailed analysis of the Automatic Rendezvous and Capture problem indicate a need for three different regions of mathematical description for the GN&C algorithms: (1) multi-vehicle orbital mechanics to the rendezvous interface point, i.e. within 100 nm, (2) relative motion solutions (such as Clohessy-Wiltshire type) from the far-field to the near-field interface, i.e. within 1 nm and (3) close proximity motion - the near-field motion where the relative differences in the gravitational and orbit inertial accelerations can be neglected from the equations of motion. Limit boundaries to these regions can be precisely defined by further analysis and will be functions of the tracking measurement accuracies and the computer resources available for the solution of the algorithms.

This paper analyzes the relative motion in Regions 2 and 3 above and presents the derivation and discussion of the general case of non-spherical gravitational perturbed relative motion. Mathematical deviations from the numerically integrated spherical gravity case and solutions from the Clohessy-Wiltshire equations are presented in the analysis. Based upon this preliminary analysis, it is recommended that further efforts be used to assess the relative position and velocity differences in Region 2 due to non-spherical gravity harmonics and that viable GN&C algorithms e developed to include these gravity perturbations (especially the effects of the first gravity harmonic, J2).

Future GN&C systems for the AR&C using relative motion sensor measurements from either an onboard laser tracking system or the GPS will be able to detect these perturbations in the relative motion. Commensurate with the accuracy of these sensor measurements, the GN&C algorithms must also be able to predict the relative motion using the gravity perturbations due to the non-spherical gravity harmonics. Increases in RCS performance (by using less rocket propellant) during AR&C operations can also be expected by the use of these more accurate GN&C systems.

Current Status:

Supporting engineering analysis proof-of-concept programs have been developed and are resident on the CRAY XMP computer system at JSC/NASA. These engineering analysis programs and concepts are described in the document, "Reference Equations of Motion for Automatic Rendezvous and Capture," by David Henderson, NASA/JSC Internal Note, to be published in October 1991.

Source / Sponsorship:

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